

Fishery Data Series No. 12-31

**Steelhead Usable Habitat Area in the Sitkoh Creek
Watershed, 2005–2007**

by

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and

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July 2012

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



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Weights and measures (metric)		General		Measures (fisheries)	
centimeter	cm	Alaska Administrative Code	AAC	fork length	FL
deciliter	dL	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	mideye-to-fork	MEF
gram	g			mideye-to-tail-fork	METF
hectare	ha			standard length	SL
kilogram	kg			total length	TL
kilometer	km				
liter	L				
meter	m				
milliliter	mL	at	@		
millimeter	mm	compass directions:			
		east	E		
		north	N		
		south	S		
		west	W		
		copyright	©		
		corporate suffixes:			
		Company	Co.	alternate hypothesis	H _A
		Corporation	Corp.	base of natural logarithm	e
		Incorporated	Inc.	catch per unit effort	CPUE
		Limited	Ltd.	coefficient of variation	CV
mile	mi	District of Columbia	D.C.	common test statistics	(F, t, χ^2 , etc.)
nautical mile	nmi	et alii (and others)	et al.	confidence interval	CI
ounce	oz	et cetera (and so forth)	etc.	correlation coefficient (multiple)	R
pound	lb	exempli gratia	e.g.	correlation coefficient (simple)	r
quart	qt	(for example)		covariance	cov
yard	yd	Federal Information Code	FIC	degree (angular)	°
		id est (that is)	i.e.	degrees of freedom	df
		latitude or longitude	lat. or long.	expected value	E
		monetary symbols (U.S.)	\$, ¢	greater than	>
		months (tables and figures): first three letters	Jan,...,Dec	greater than or equal to	≥
		United States	®	harvest per unit effort	HPUE
		(adjective)	™	less than	<
Time and temperature		United States of America (noun)	U.S.	less than or equal to	≤
day	d	U.S.C.	USA	logarithm (natural)	ln
degrees Celsius	°C	U.S. state	United States Code	logarithm (base 10)	log
degrees Fahrenheit	°F		use two-letter abbreviations (e.g., AK, WA)	logarithm (specify base)	log ₂ , etc.
degrees kelvin	K			minute (angular)	'
hour	h			not significant	NS
minute	min			null hypothesis	H ₀
second	s			percent	%
				probability	P
				probability of a type I error (rejection of the null hypothesis when true)	α
				probability of a type II error (acceptance of the null hypothesis when false)	β
Physics and chemistry				second (angular)	"
all atomic symbols				standard deviation	SD
alternating current	AC			standard error	SE
ampere	A			variance	
calorie	cal			population	Var
direct current	DC			sample	var
hertz	Hz				
horsepower	hp				
hydrogen ion activity (negative log of)	pH				
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

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ABSTRACT

We conducted seasonal fish use snorkel surveys in the Sitkoh Creek watershed on Chichagof Island, in Southeast Alaska between 2005 and 2007. For both adult and juvenile steelhead *Oncorhynchus mykiss*, we identified the stream reaches they occupied and calculated total usable habitat area. Channel bed width and stream reach length were measured to approximate usable habitat area for adult and juvenile steelhead. Adult steelhead were limited to mainstem reaches and occupied 12.72 ha of this habitat; juvenile steelhead utilized both mainstem and tributary reaches ($n = 5$), and were observed occupying a total of 15.42 ha across the watershed. A 7-year stock assessment project at Sitkoh Creek found a mean adult escapement of 541 steelhead with juvenile emigration averaging 2,434 smolts. When combined with this study, this production yields an estimate of 35 adult steelhead and 158 smolt per hectare of total usable habitat area. This report completes the second phase of the project at Sitkoh Creek and the findings will be incorporated into a habitat-based steelhead carrying capacity model for Southeast Alaska.

Key words: stream habitat, *Oncorhynchus mykiss*, Sitkoh Creek, steelhead, snorkel survey, usable area.

INTRODUCTION

Southeast Alaska (SEAK) is known to anglers for the high quality stream habitat that provides abundant opportunities to catch steelhead *Oncorhynchus mykiss*. Steelhead stocks have been managed conservatively since 1994 when the Board of Fisheries adopted restrictive regulations in response to concerns over population declines. However, given recent liberalization of federal subsistence steelhead regulations, there is an imminent need to better understand steelhead populations with respect to habitat capability. Small populations of steelhead are considered particularly vulnerable to overharvest and habitat degradation (Nehlsen et al. 1991). Therefore a better understanding of how particular habitats contribute to steelhead production and rearing potential is important to the management of this species. In an effort to address these concerns, the Alaska Department of Fish and Game, Division of Sport Fish (ADF&G-SF) has outlined a research approach in its *Strategic Plan for Southeast Alaska Steelhead Research and Monitoring Program*¹. The overall goal of this research is to collect information to be used in the development of a steelhead habitat capability model for SEAK. Achievement of this goal will augment a key strategy in the ADF&G-SF Strategic Plan: to develop and implement research programs to assess the relationships between fish production and associated habitats. We have begun developing the necessary parameters for this model in the Sitkoh Creek, Peterson Creek, Sashin Creek and Ratz Creek watersheds, and future efforts associated with the overall Strategic Plan will incorporate data from other systems to enhance the portability of the model. This document will focus on activities carried out in the Sitkoh Creek watershed.

Through this study we are exploring alternative stock assessment methods (habitat-based model), similar to efforts conducted by researchers in British Columbia and Oregon (Tautz et al. 1992; Bocking et al. 2005; Cramer and Ackerman 2009a). Tautz et al. (1992) described 3 categories of information used in developing their steelhead carrying capacity and production model for the Skeena River in British Columbia: distribution, fish use, and production. Distribution referred to the number and extent of streams or tributaries likely to contain steelhead; fish use involved estimating total area and total usable area of potential steelhead bearing streams; and production included the possible number of steelhead smolts produced from a stream's expected usable area.

¹ Harding, R. D., A.P. Crupi, D.J. Reed. *Unpublished*. Strategic plan for Southeast Alaska steelhead research and monitoring program. Alaska Department of Fish and Game, Division of Sportfish. Douglas, AK.

This production estimate was based on demographic data from decades of research on the Keogh River (Ward 2000). We intend to refine the Tautz et al. model by calculating total steelhead usable area from stream reaches actually occupied by steelhead, as well as by integrating population productivity from each watershed in which usable area is calculated.

Our strategy for developing this steelhead habitat model requires production and habitat data for 8 steelhead bearing systems with greater than 5 years of escapement data. Four of the systems will provide adult production data, while the other four systems will contribute smolt and adult production estimates to the model. Habitat data, including usable area, will be collected for all eight systems. Since regional steelhead stocks are generally considered stable (Harding 2005), this is an ideal opportunity to pursue system specific stock assessment information with regards to habitat quality and availability. This project was initiated in the Sitkoh Creek watershed, beginning with a characterization of stream habitats to identify potential steelhead distribution (Crupi et al. *in prep*), followed by a seasonal assessment of habitat use by juvenile and adult steelhead. Given that the juvenile steelhead population is relatively unexploited (other than natural mortality) and that the adult steelhead fishery is primarily catch and release, though the level of hooking mortality is unknown but estimated to be less than 5%, we believe the population to be at carrying capacity. The existing long-term steelhead production study at Sitkoh Creek will provide smolt and adult production data for Sitkoh Creek (Love and Harding 2008, 2009, *in prep a, b*). This report will summarize the fish use phase of this project at Sitkoh Creek.

OBJECTIVES

Phase II (Fish Use) objectives that will be addressed in pursuit of the overall goal:

- Estimate usable area for juvenile and adult steelhead in the Sitkoh Creek watershed such that the estimate is within 35% of the actual value 95% of the time.

STUDY AREA

Sitkoh Creek (ADF&G Anadromous Waters Catalog Stream No. 113-59-10040) is located in northern SEAK on Chichagof Island near Chatham Strait (Figure 1). Flowing from the outlet of Sitkoh Lake the mainstem of Sitkoh Creek runs approximately 6 km to salt water at Sitkoh Bay. As identified in the Anadromous Waters Catalog (AWC), the stream is occupied by most salmonid species found in the region including: pink, coho, sockeye, and chum salmon; cutthroat and steelhead/rainbow trout; and Dolly Varden char (Johnson and Daigneault 2008). Several second order tributary streams (Strahler 1952) drain into Sitkoh Lake and Creek and most of these water bodies are inhabited by one or more of these salmonid species.

Sitkoh Creek is an important freshwater fishery in the Sitka Management Area (Jones et al. 1991, Brookover et al. 1999). The United States Forest Service (USFS) maintains 2 popular public-use cabins on Sitkoh Lake, with visitor access primarily by floatplane, boat and all-terrain vehicle. ADF&G-SF staff operated a weir at the mouth of Sitkoh Creek from April to June between 2003 and 2009 coinciding with the adult steelhead spawning run, and the abundant outmigration of smolts (steelhead, cutthroat trout, Dolly Varden, and salmon species). Fishery technician counts of steelhead, both smolt and adult, averaged 2,434 and 541 respectively during this period (Love and Harding 2008, 2009, *in prep a, b*).



Figure 1.—Location of Sitkoh Creek and watershed in Southeast Alaska.

The size of the watershed is approximately 50 km² including Sitkoh Lake (2 km²). There are approximately 111 km of stream mapped within the watershed. More than half of the streams in the network are classified as high-gradient headwater streams. The remaining streams include the mainstem of Sitkoh Creek and over 50 km of lower gradient 2nd order tributary streams. Timber management included an extensive harvest (19% of the watershed) of the spruce-hemlock forest surrounding the lake between 1969 and 1974. A thorough synopsis of watershed statistics, channel type classifications and stream habitat surveys for the Sitkoh Creek watershed can be found in Crupi et al. (*in prep*).

METHODS

FISH HABITAT USE ASSESSMENT

During Phase I of this project (Crupi et al. *in prep*), streams in the Sitkoh Creek watershed were mapped and classified according to landscape forming processes (fluvial process groups), following established stream surveying protocols². The core components of the protocol were built upon the *USFS Region 10 Tier II Aquatic Habitat Survey* (USFS 2001), and the *USFS Channel-type Users Guide* (USFS 1992), which in combination provide key data necessary for conducting coarse assessments of the physical habitat within a watershed that may be important to fish. This characterization distinguished individual stream reaches, defined as specified homogeneous lengths of a stream greater than 100 m in length. The classification of stream reaches into process groups and channel types is important because it was used as the sampling unit for steelhead presence and stream habitat area calculations.

This report covers the fish use phase of the project where the objective was to identify the individual stream reaches occupied by steelhead and then calculate the total area used by both adult and juvenile steelhead, excluding Sitkoh Lake. To effectively identify steelhead usable area, we snorkel surveyed the entire mainstem and all significant tributaries below geologic barriers to document the presence of steelhead. Underwater observation has been identified as being one of the most functional and cost-effective methods available to acquire information on fish abundance, behavior, and distribution over long reaches (Hankin and Reeves 1988; Dolloff et al. 1996).

Snorkel surveys were performed seasonally by 2-person crews in the tributary reaches, while the larger mainstem required 2 snorkel crews. Previous research identified patterns in juvenile steelhead distribution wherein fish migrated between mainstem and tributary habitats during different seasons (Bramblett et al. 2002; USFS-Forestry Science Laboratory 2005 unpublished data). To account for this seasonal variation and to maximize our potential to observe steelhead within all reaches actually occupied, we repeated sampling in the spring, summer and fall seasons over 2 years. When steelhead were observed we documented the stream reach, spatial location (i.e., GPS coordinates), species and number of fish in each size class (0–50 mm, 51–150 mm, 150–200 mm, and >200 mm), as well as the meso-habitat occupied by these fish. Meso-habitat was categorized as scour pools (plunging, lateral, mid-channel pools), backwater pools (eddy current formed by obstruction), glides (little surface disturbance with gradient 0–2%), and riffles (surface disturbance and gradient 2–4%).

² Frenette, B. J., J. V. Nichols, D. P. Gregovich, C. A. Schmale, and K. M. Smikrud. *Unpublished*. Stream survey user guide. Alaska Department of Fish and Game, Division of Sportfish. Douglas, AK.

STEELHEAD USABLE HABITAT AREA ESTIMATE

In addition to snorkel surveys, field crews acquired channel bed width (CBW) measurements using a range finder (>10 m) or measuring tape (<10 m), at intervals of up to 100m along the reach, with a minimum sample size of 3 measurements per reach. These measurements were used to calculate average channel bed width (\overline{cbw}_i) for each reach, necessary to determine total area and total usable area. In order to meet the precision criterion of estimating mean CBW for each reach, sample size was determined based on variation observed in CBW within reach during initial field sampling. We calculated the sample CV for each reach ($CV = \text{sample SD} / \text{mean}$) after initial field sampling to determine if additional sampling was required. If reach sampling was not sufficient the field crew calculated an additional approximate sample CV ($CV_a = \text{sample range} / 4 / \text{mean}$). Using the larger of CV or CV_a , we estimated how much additional sampling effort was required for the reach. When additional samples were required they were distributed roughly uniformly across the reach at points approximately mid-distance from initial sampling locations as recorded by GPS.

While in the field, snorkel survey crews determined whether the surveyed reach was occupied by steelhead. In survey reaches where steelhead were observed, the entire area of that reach was considered usable habitat. When steelhead were not observed during any of the seasonal surveys the reach was not considered usable habitat. The following calculations were done for both juveniles and spawning adult steelhead.

The amount of usable habitat of the i^{th} usable reach (u_i) was calculated as:

$$u_i = l_i \times \overline{cbw}_i \quad (1)$$

where:

l_i = total length of reach i ; and

\overline{cbw}_i = average channel bed width of reach i .

The total usable area in the system (U) was calculated as:

$$U = \sum u_i \quad (2)$$

When the reach was identified as not being used by steelhead, the area of that reach was considered non-usable. The non-usable area of the j^{th} non-usable reach (v_j) and total non-usable area (V) was calculated in the same manner as usable area (equations 1 and 2).

The total area (T) was calculated as:

$$T = U + V \quad (3)$$

When the identification of a potential steelhead was uncertain, the stream reach was not considered occupied by steelhead. Juvenile steelhead smaller than 50mm were particularly difficult to distinguish from cutthroat trout. Through repeated seasonal surveys we improved our likelihood of observing steelhead within these reaches, but acknowledge that it was possible we

did not detect and/or identify all steelhead present. Therefore, the total usable area estimate (U) is considered a minimum.

RESULTS

FISH HABITAT USE ASSESSMENT

Between October 2005 and October 2007 we conducted 7 snorkel survey trips to assess the seasonal distribution patterns of adult and juvenile steelhead (Table 1), necessary to estimate steelhead usable habitat area. Given the migratory nature of steelhead, this temporal approach allowed us to detect steelhead within a broad range of occupied habitats. We repeated surveys on the majority of the stream reaches identified as potential steelhead habitat for a combined total of 114 km of stream habitat snorkel surveyed for steelhead presence. The seasonal use of stream reaches by steelhead, cutthroat trout, coho salmon, and Dolly Varden for spawning and rearing is presented in Table 2.

Table 1.—Snorkel survey trip timing and distance sampled in Sitkoh Creek watershed, 2005–2007.

Season-trip ID	Survey dates	# Reaches snorkeled	Distance snorkeled (km)
Fall – SKO55	10/5–10/10/2005	28	13.40
Winter – SKO65	11/30–12/4/2005	6	3.10
Spring – SKO16	4/18–4/28/2006	41	25.92
Late spring SKO26	6/12–6/16/2006	6	3.68
Summer – SKO36	7/13–7/19/2006	39	22.57
Fall – SKO36	10/25–10/30/2006	39	22.38
Spring – SKO17	5/17–5/25/2007	40	23.00
Total		199	114.06

Adult steelhead were detected in all mainstem stream reaches of Sitkoh Creek. Adult steelhead were observed only during spring surveys, and were not observed in any tributary reaches during any season. In general, steelhead were observed in the mainstem and lower reaches of adjacent tributary streams with steelhead presence/absence and associated stream reach labeled in Figure 2. One particular stream reach entering the west end of Sitkoh Lake (F4) was verified for juvenile steelhead presence, though this reach was a dry channel bed until the final survey when its flow extended down to the lake.

Adult steelhead occupied each reach of the Sitkoh Creek mainstem, although during each spring snorkel survey from 2005 to 2007, the majority of adult steelhead were observed in the lowest reach of the mainstem (M5) (Figure 3, Table 3). Figure 3 displays the combined distribution of 59 observed steelhead in April 2006 and 128 in May 2007. These mapped results are also consistent with our 2005 snorkel index survey observations where adult steelhead were concentrated in the lowest reach (Table 3).

Individual locations of juvenile steelhead observed during 4 snorkel survey sampling events (June, July, October 2006, and May 2007) show fish distribution throughout the mainstem of Sitkoh Creek, and occasional occurrences were observed within tributaries (Figure 4).

Table 2.—Seasonal fish use by species of each stream reach in the Sitkoh Creek watershed. (CHTYP = channel type, Spring= Sp, Summer=S, Fall=F and * indicates fish observed in spawning condition)

Basin reach	Reach CHTYP	Steelhead	Cutthroat trout	Coho salmon	Dolly Varden
A1	PA0				
A2	MC1		Sp*, S, F	Sp, S, F	
A3	MC2	Sp	Sp*, S, F	Sp, S, F	Sp, S, F
A4	HC3		Sp, S, F		Sp, S, F
A5	MM1		Sp, S, F	Sp, S, F	Sp, S, F
B1	HC3		S, F		S, F
B2	HC2		S, F		S, F*
B3	AF2	Sp, S, F	S, F	S, F	S, F
B4	MM0		F		
B5	MM1		S, F		S, F
B6	MM0		S	S, F	
C1	MC2		Sp, S, F*	F	Sp, S, F
C2	MM2	Sp, S	Sp, S, F*	F*	Sp, S, F*
C3	FP3	Sp	S, F	Sp, S, F*	Sp, S, F*
D1	HC4		S, F		S
D2	MM2		Sp, S, F	Sp, S, F*	S, F
D3	HC2		S, F		S
D4	FP4		Sp, F	S, F*	F*
E1	HC6				
E2	AF1				
F1	HC3		S		
F2	AF1		S	Sp	S
F4	AF1	Sp	Sp*	F	F
G1	HC5				S, F
H1	HC5				
I1	HC3		F		S, F
I2	AF2		Sp, S, F	S	Sp, S, F*
I3	AF1		Sp*, S	S	S, F*
J1	HC6		Sp, S, F		Sp, S
J2	MM1		Sp, S, F	Sp, S, F	
J3	AF1		Sp, S, F	Sp, S, F	Sp, S, F
K1	HC6		F	F	
K2	AF2		Sp*, S, F	S, F	S, F
K3	HC4		Sp, S, F	S	S, F*
K4	MM1		Sp, F	S	Sp
K5	AF1		Sp*, S, F*	Sp, S, F	Sp, S, F
M1	FP5	Sp*, S, F	Sp*, S, F*	Sp*, S, F*	Sp*, S, F*
M2	LC1	Sp*, S, F	Sp*, S, F*	Sp*, S, F*	Sp*, S, F*
M3	FP4	Sp*, S, F	Sp*, S, F*	Sp*, S, F*	Sp*, S, F*
M4	MM2	Sp*, S, F	Sp*, S, F*	Sp*, S, F*	Sp*, S, F*
M5	LC2	Sp*, S, F	Sp*, S, F*	Sp*, S, F*	Sp*, S, F*

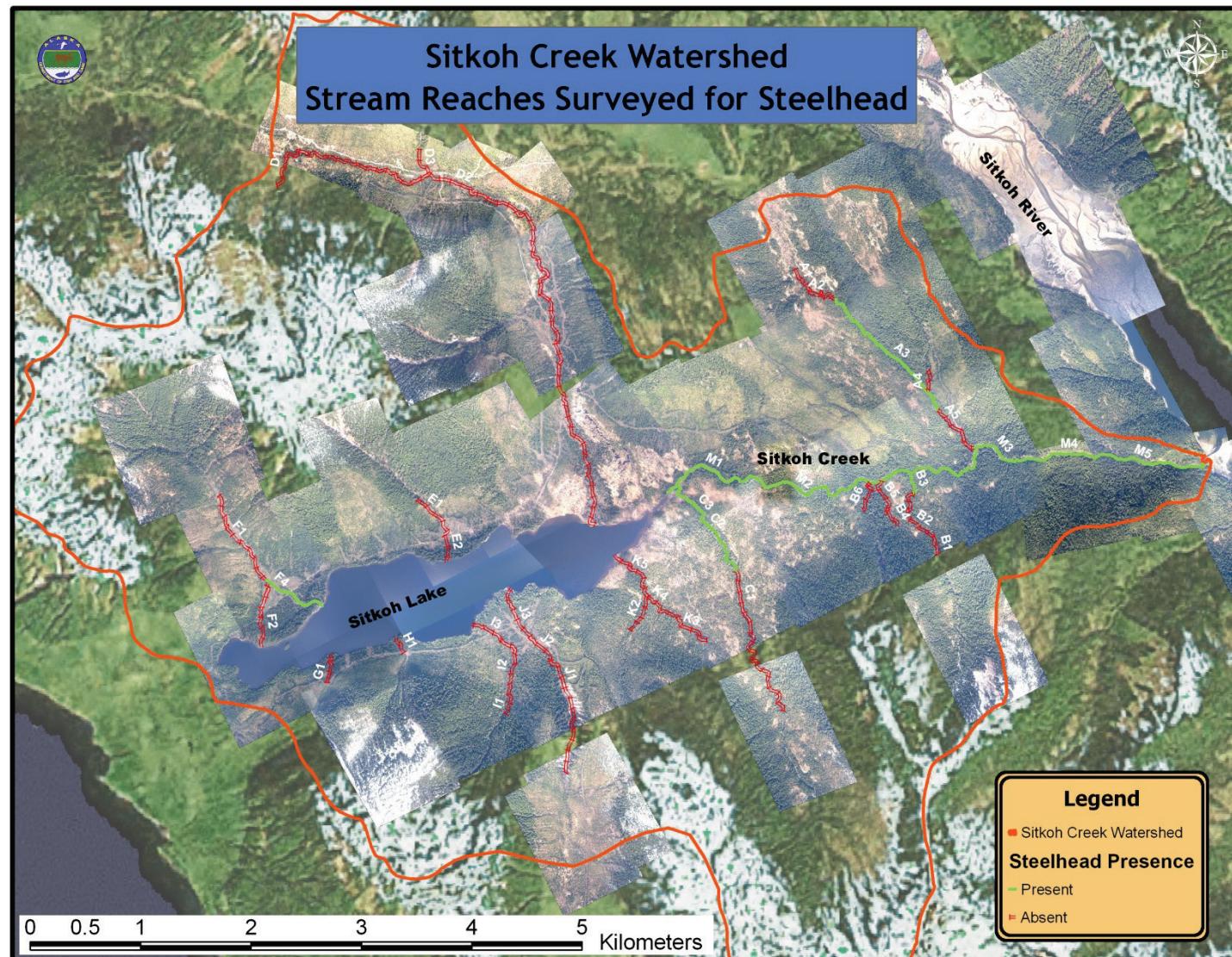


Figure 2.—Snorkel survey results for steelhead in the Sitkoh Creek watershed.

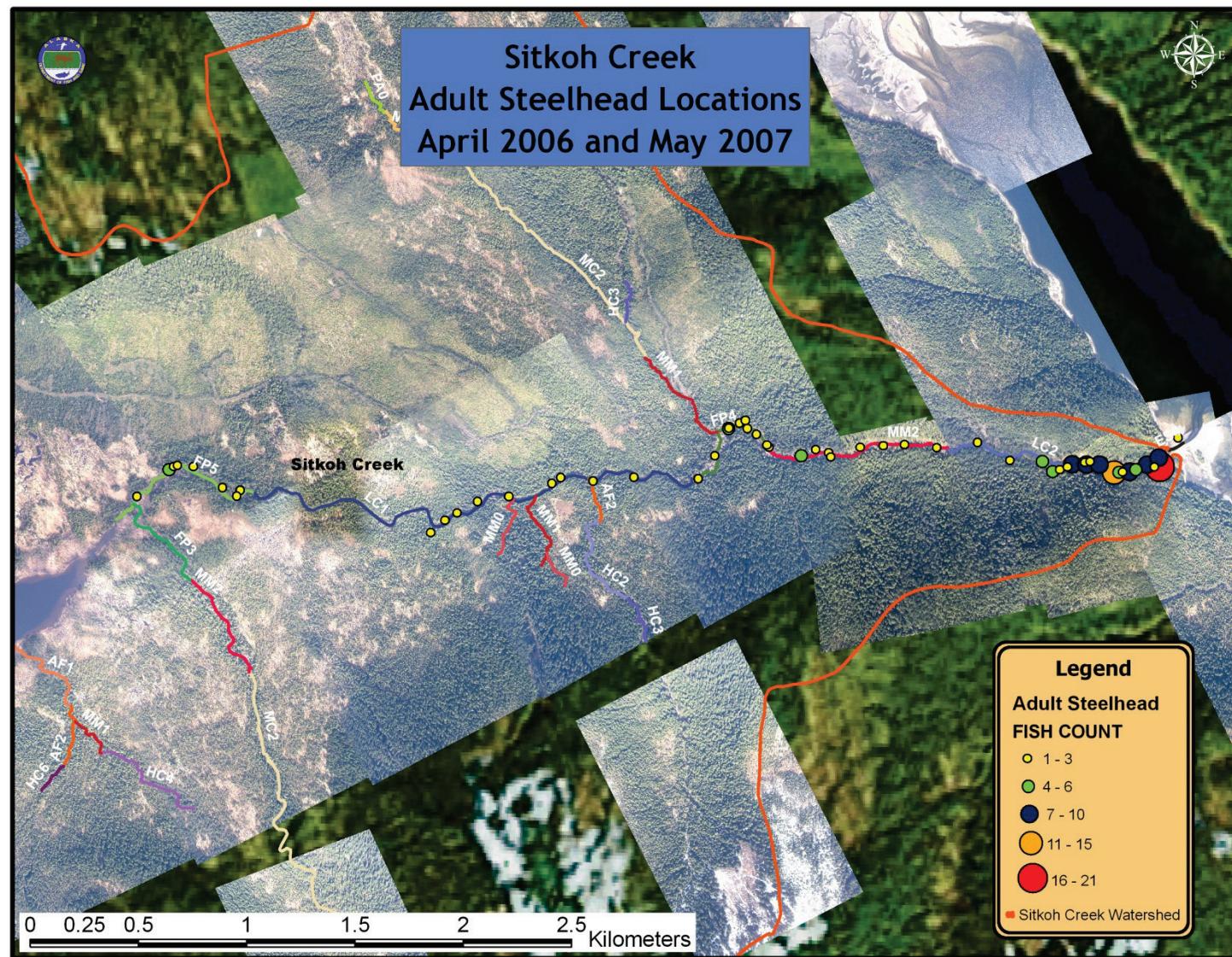


Figure 3.—Locations of steelhead during spring snorkel surveys of Sitkoh Creek in 2006 and 2007.

Table 3.—Results (counts and % of total) for reaches within the mainstem of Sitkoh Creek collected during snorkel surveys, 2005–2007.

Basin reach	Channel type	Distance snorkeled (km)	Steelhead count		Steelhead count		Steelhead count		Steelhead count	
			SKO17 (5/21–22/07)	% Total (SKO17)	SKO16 (4/24–25/06)	% Total (SKO16)	SKO45 (5/18/05)	% Total (SKO45)	SKO35 (5/10/05)	% Total (SKO35)
M1	FP5	0.82	13	10.2	0	0.0	8	3.2	9	3.8
M2	LC1	1.55	20	15.6	0	0.0	10	4.0	39	16.3
M3	FP4	0.62	11	8.6	4	6.8	11	4.4	15	6.3
M4	MM2	0.88	15	11.7	4	6.8	23	9.3	38	15.9
M5	LC2	1.12	69	53.9	51	86.4	196	79.0	138	57.7
Total		4.99	128	100.0	59	100.0	248	100.0	239	100.0

Within the mainstem we found that juvenile steelhead were distributed more throughout the middle reaches (M2, M3, M4). Three complete surveys (spring - SKO17, summer - SKO36, and fall - SKO46) of the mainstem were used to calculate densities of observed juvenile steelhead (Figure 5). The middle reach (M3) consistently had the greatest density of juvenile steelhead, where habitat is characterized by a high density of large wood accumulations and detailed in Crupi et al. (*in prep*). To illustrate the differences between the distribution of various size classes of juvenile steelhead we present data from the complete summer snorkel survey (SKO36) when juvenile counts were the highest ($n = 1,140$) and instream flows were low (23.9 cfs). Juvenile steelhead in the 50 mm – 150 mm size class occupied the middle reach in the highest density (Figure 6). Juvenile steelhead in the 150 – 200 mm size class were also observed more frequently in the middle reaches, although densities in the first and last reach were slightly higher than the distribution of the smaller size class (Figure 7).

We also mapped the observed distribution of *O. mykiss* greater than 200 mm who possessed morphological characteristics of resident rainbow trout and not those of anadromous steelhead (Figure 8). During the July 2006 snorkel survey, after the emigration of adult steelhead, higher densities of fish in this size class were concentrated in the middle reaches of the mainstem, though at lower densities than the smaller size classes of juvenile steelhead.

There were several habitat characteristics in common for stream reaches occupied by steelhead of all size classes (Table 4). These channels tended to be of greater width (range 4.75 – 30.84 m), moderate gradient (range 1.2 – 5.2%), and substrates dominated by coarse gravels and small cobbles (substrate definitions in Appendix A) based on 7 of the 10 stream reaches occupied by steelhead.

When we observed steelhead during the snorkel surveys we documented the meso-habitat within the stream reach where we observed them. This information was recorded for 659 adult and 1,666 juvenile steelhead. We found that adult steelhead were most frequently observed in scour pool habitat (75%) as were juvenile steelhead (60%) (Figure 9). As a general observation, the deeper and faster water found in scour pools and glides tended to hold the majority of adult steelhead. For juvenile steelhead, shallow riffles were also found to be important habitats.

STEELHEAD USABLE HABITAT AREA ESTIMATE

To calculate usable habitat area for steelhead in the Sitkoh Creek watershed we collected 474 channel bed width measurements in 41 stream reaches. The total area (T) of stream reaches identified for potential steelhead distribution equaled 26.23 ha. We observed adult steelhead in the entire mainstem during spring snorkel surveys; therefore all five reaches were used to calculate adult usable habitat area totaling 12.72 ha. In addition to the mainstem, juvenile steelhead were positively observed in 5 tributary stream reaches for a combined total of 15.42 ha of usable habitat area (Table 5).

As we develop the steelhead carrying capacity model for SEAK it will be important to provide the metrics of usable area in terms of production. The Sitkoh Creek watershed will be 1 of 8 systems incorporated into this model representing one of two lake systems in northern SEAK. The recent 7-year average number of steelhead counted through the Sitkoh Creek weir was 541 adults (Table 6) (Love and Harding 2008, 2009, *in prep a, b*). Therefore the average number of adults per hectare of total usable habitat area equals 35.15. Mean 7-yr juvenile production was 2,434 smolts resulting in an estimate of 157.8 smolts per hectare of usable habitat area.

Table 4.—Sitkoh Creek stream reach habitat characteristics relative to steelhead presence. (CHTYP = channel type).

Basin reach	Reach CHTYP	Reach ID	Reach length (km)	Bankfull width (m)	Channel bed width (m)	Gradient (%)	Incision depth (m)	Dominant substrates	Large wood density	Key wood density	Macro pool density	Steelhead present
A1	PA0	163973	0.12	1.0	1.90	1.3	1.00	SS/ORG	60.82	17.38	69.51	No
A2	MC1	164005	0.46	7.0	2.84	3.3	6.00	CGR/SC/BR	17.41	21.76	50.04	No
A3	MC2	164035	1.40	10.0	5.62	3.0	15.00	CGR/VCG/MGR	228.99	64.2	59.92	Yes
A4	HC3	164179	0.23	12.0	4.25	8.9	17.00	CGR/SC/SB	238.75	145.9	110.53	No
A5	MM1	164223	0.52	9.0	9.60	1.7	1.00	MGR/SC/LC	266.12	36.38	57.44	No
B1	HC3	164524	0.25	14.0	7.00	9.9	25.00	LC/CGR/SC	233.51	173.12	132.86	No
B2	HC2	164615	0.50	10.0	5.82	5.8	3.00	LC/SB/SC	49.91	35.94	31.94	No
B3	AF2	850021	0.23	10.5	4.75	5.2	1.00	CGR/SC/LC	108.02	77.78	69.13	Yes
B4	MM0	850019	0.19	1.2	1.30	4.7	0.75	MGR/FGR/CGR	51.75	51.75	46.58	No
B5	MM1	850020	0.38	2.0	2.79	5.5	1.40	CGR/SC/MGR	130.39	62.58	31.29	No
B6	MM0	164403	0.30	1.5	1.48	5.2	0.50	MGR/CGR/FGR	122.15	39.62	59.42	No
C1	MC2	164787	1.61	13.0	9.07	2.6	20.00	SC/LC/FGR	218.58	34.87	60.40	No
C2	MM2	164502	0.57	16.0	12.18	2.2	1.50	CGR/SC/SS	302.23	81.30	61.86	Yes
C3	FP3	850018	0.51	11.0	10.08	2.2	0.75	CGR/SC/SS	246.1	39.38	45.28	Yes
D1	HC4	163812	1.12	5.0	3.71	6.1	25.00	SB/LC/BR	42.04	24.15	23.25	No
D2	MM2	163582	3.83	12.0	6.74	1.8	1.00	SB/LC/SC	208.02	53.51	31.06	No
D3	HC2	163578	0.28	4.0	3.25	15.5	7.00	SC/VCG/FGR	156.20	88.75	67.45	No
D4	FP4	164137	1.80	12.0	9.18	1.5	1.00	VCG/VFG/SS	106.55	30.52	30.52	No
E1	HC6	164411	0.44	10.0	3.33	12.7	80.00	SB/LMB/CGR	158.17	85.87	58.75	No
E2	AF1	850016	0.24	8.0	2.13	4.4	0.00	ORG				No
F1	HC3	164439	1.05	14.0	7.17	4.5	20.00	CGR/LC/MRG	152.97	9.56	63.10	No
F2	AF1	164611	0.66	32.0	3.85	2.3	0.50	SC/CGR/SS	83.71	18.26	50.23	No
F4	AF1	164611	0.62	9.0	7.87	4.0	0.75	VCG/SC/FGR				Yes
G1	HC5	164831	0.29	3.5	1.92	15.8	3.00	CGR/VCG/VFG	104.39	62.63	20.88	No
H1	HC5	164702	0.19	8.0	2.79	19.7	2.00	CGR/VCG/FGR	179.67	110.97		No
I1	HC6	164907	0.23	7.0	4.00	15.5	10.00	LC/SC/SB	73.91	78.26	147.83	No
I2	HC2	164362	0.67	10.5	5.30	7.9	1.75	SC/VCG/LC	265.67	59.7	88.06	No
I3	AF1	164721	0.33	8.0	4.55	1.7	1.00	VCG/MGR/FGR	266.96	92.99	113.98	No
J1	HC6	164889	1.44	7.0	4.45	7.7	75.00	SC/CGR/BR	310.72	180.44	64.79	No
J2	MM1	164697	0.39	10.0	4.10	4.3	1.00	LC/SC/MGR	105.44	69.44	48.86	No
J3	AF1	850015	0.44	10.0	5.17	2.2	0.50	VCG/CGR/FGR	120.96	68.47	70.75	No
K1	HC6	164801	0.51	2.5	2.10	11.7	15.00	BR/SC/CGR	167.89	65.18	75.06	No
K2	AF2	164624	0.31	10.0	3.03	6.9	2.50	SC/MGR/FGR	208.49	105.85	16.04	No
K3	HC4	164666	0.32	9.0	2.38	6.8	11.00	LC/MGR/BR	172.52	46.21	52.37	No
K4	MM1	850017	0.20	7.0	3.73	3.3	8.00	VCG/CGR/SC	90.76	65.55	35.29	No
K5	AF1	164579	0.46	10.0	3.41	1.8	1.00	FGR/VFG/VCG	112.92	73.83	80.35	No
M1	FP5	164369	0.85	27.0	30.84	1.8	1.50	MGR/FGR/SS	186.66	46.96	97.44	Yes
M2	LC1	164370	2.30	18.0	16.75	1.6	8.00	LC/SC/VCG	63.46	13.91	55.20	Yes
M3	FP4	164324	0.64	22.0	20.79	2.0	1.00	CGR/VCG/MGR	216.04	48.53	43.83	Yes
M4	MM2	164252	0.89	30.5	23.83	1.4	2.50	CGR/VCG/SC	160.24	40.62	68.83	Yes
M5	LC2	164279	1.07	20.0	24.28	1.2	1.50	CGR/VCG/SC	235.52	38.32	28.04	Yes

Table 5.—Stream reach measurements used in calculation of usable habitat area for steelhead in Sitkoh Creek.

Basin reach	Channel type	Reach length (m)	#CBW (n)	Mean channel bed width (m)	CV	STDEV (+/-)	Total area (ha)	Steelhead present	Usable area (ha)
A1	PA0	191.02	17	1.90	0.16	0.31	0.04	No	
A2	MC1	466.02	11	2.84	0.20	0.57	0.13	No	
A3	MC2	1497.77	16	5.62	0.33	1.88	0.84	Yes	0.84
A4	HC3	227.66	10	4.25	0.40	1.72	0.10	No	
A5	MM1	547.23	5	9.60	0.11	1.08	0.53	No	
B1	HC3	264.11	7	7.00	0.33	2.33	0.18	No	
B2	HC2	539.28	14	5.82	0.30	1.76	0.31	No	
B3	AF2	230.48	8	4.75	0.23	1.07	0.11	Yes	0.11
B4	MM0	193.97	12	1.30	0.55	0.71	0.03	No	
B5	MM1	391.39	12	2.79	0.25	0.69	0.11	No	
B6	MM0	327.00	10	1.48	0.47	0.70	0.05	No	
C1	MC2	1638.43	31	9.07	0.28	2.23	1.49	No	
C2	MM2	571.50	14	12.18	0.36	4.36	0.70	Yes	0.70
C3	FP3	555.64	8	10.08	0.49	4.96	0.56	Yes	0.56
D1	HC4	599.59	7	3.71	0.22	0.81	0.22	No	
D2	MM2	3800.75	40	6.74	0.31	2.07	2.56	No	
D3	HC2	285.10	4	3.25	0.20	0.65	0.09	No	
D4	FP4	1847.03	17	9.18	0.33	2.72	1.69	No	
E1	HC6	469.91	6	3.33	0.19	0.63	0.16	No	
E2	AF1	263.19	4	2.13	0.12	0.25	0.06	No	
F1	HC3	1038.38	11	7.17	0.14	1.00	0.74	No	
F2	AF1	610.07	7	3.85	0.26	1.01	0.23	No	
F4	AF1	623.88	13	7.87	0.22	1.71	0.49	Yes	0.49
G1	HC5	287.84	9	1.92	0.14	0.27	0.06	No	
H1	AF1	177.92	7	2.79	0.63	1.75	0.05	No	
I1	HC6	149.66	4	4.00	0.10	0.41	0.06	No	
I2	HC2	669.44	23	5.30	0.37	1.96	0.36	No	
I3	AF1	333.45	11	4.55	0.19	0.85	0.15	No	
J1	HC6	1131.73	12	4.45	0.23	1.04	0.50	No	
J2	MM1	398.00	5	4.10	0.13	0.55	0.16	No	
J3	AF1	433.24	9	5.17	0.35	1.79	0.22	No	
K1	HC6	155.71	6	2.10	0.34	0.71	0.03	No	
K2	AF2	314.07	13	3.03	0.25	0.75	0.10	No	
K3	HC4	593.70	14	2.38	0.16	0.38	0.14	No	
K4	MM1	232.85	7	3.73	0.32	1.18	0.09	No	
K5	AF1	505.06	11	3.41	0.27	0.92	0.17	No	
M1	FP5	824.92	11	30.84	0.40	12.41	2.54	Yes	2.54
M2	LC1	2432.26	16	16.75	0.32	4.99	4.07	Yes	4.07
M3	FP4	624.45	7	20.79	0.31	6.43	1.30	Yes	1.30
M4	MM2	880.42	12	23.83	0.22	5.22	2.10	Yes	2.10
M5	LC2	1115.45	9	24.28	0.27	6.52	2.71	Yes	2.71
Total		28439.56					26.23		15.42

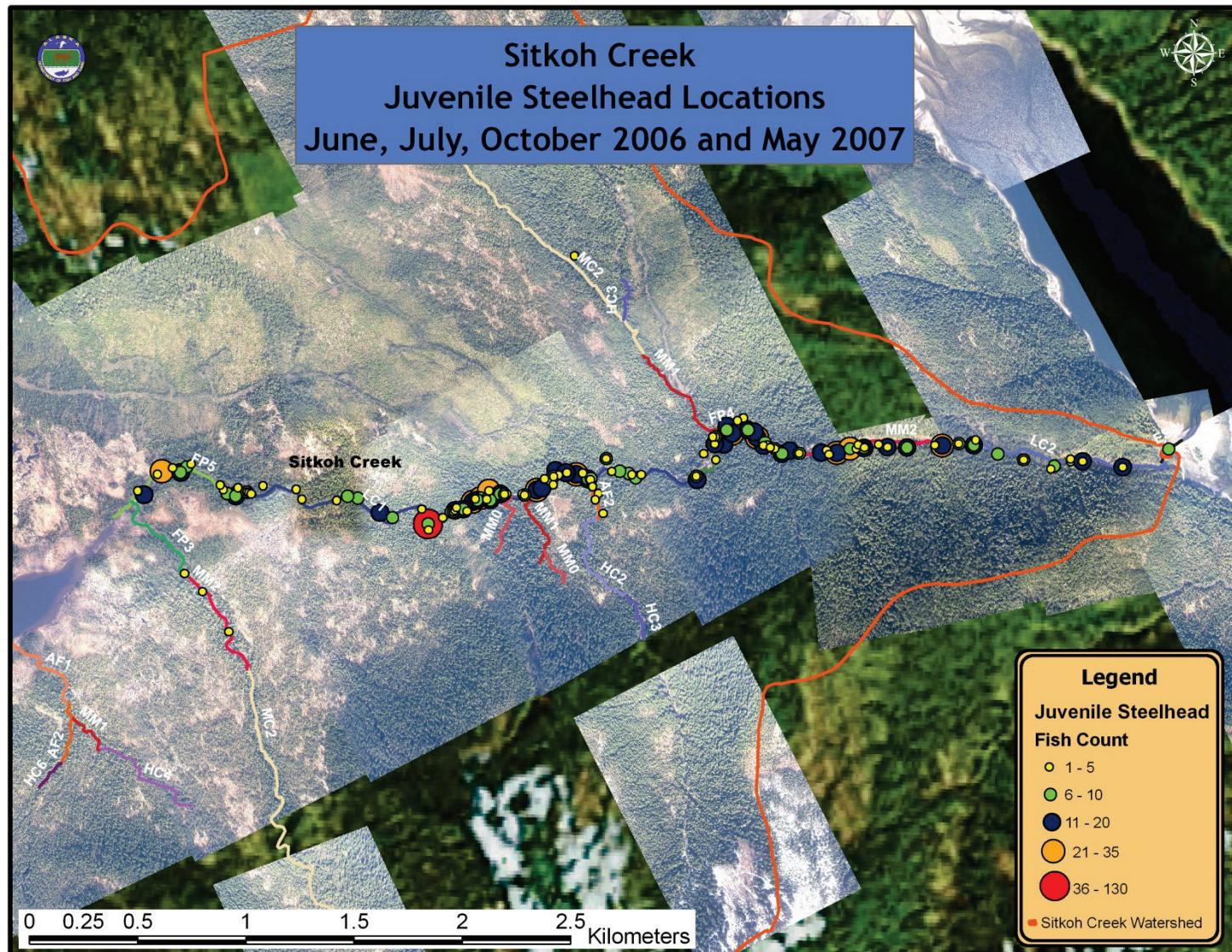


Figure 4.—Juvenile steelhead distribution throughout Sitkoh Creek in 2006 and 2007.

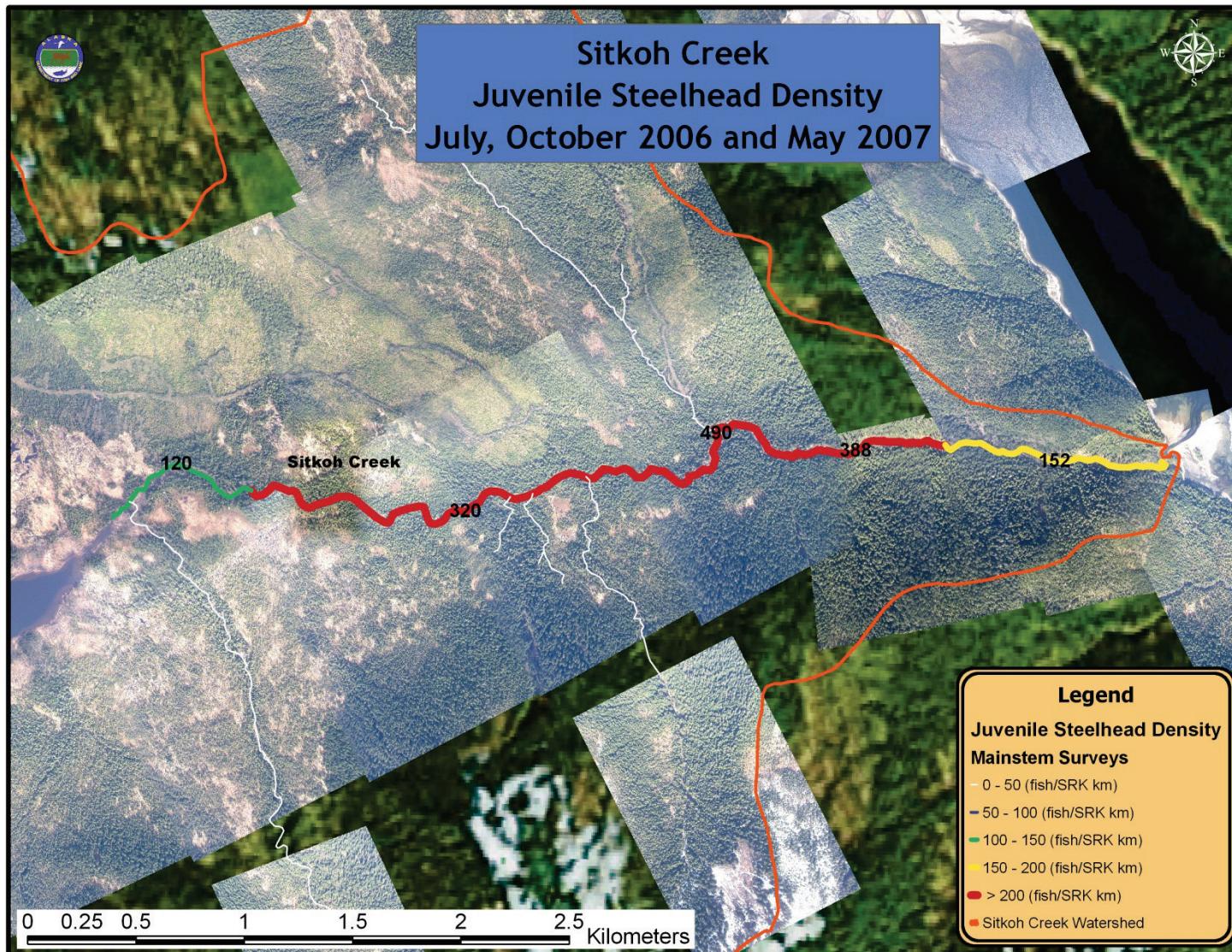


Figure 5.—Juvenile steelhead observed density throughout Sitkoh Creek in 2006 and 2007.

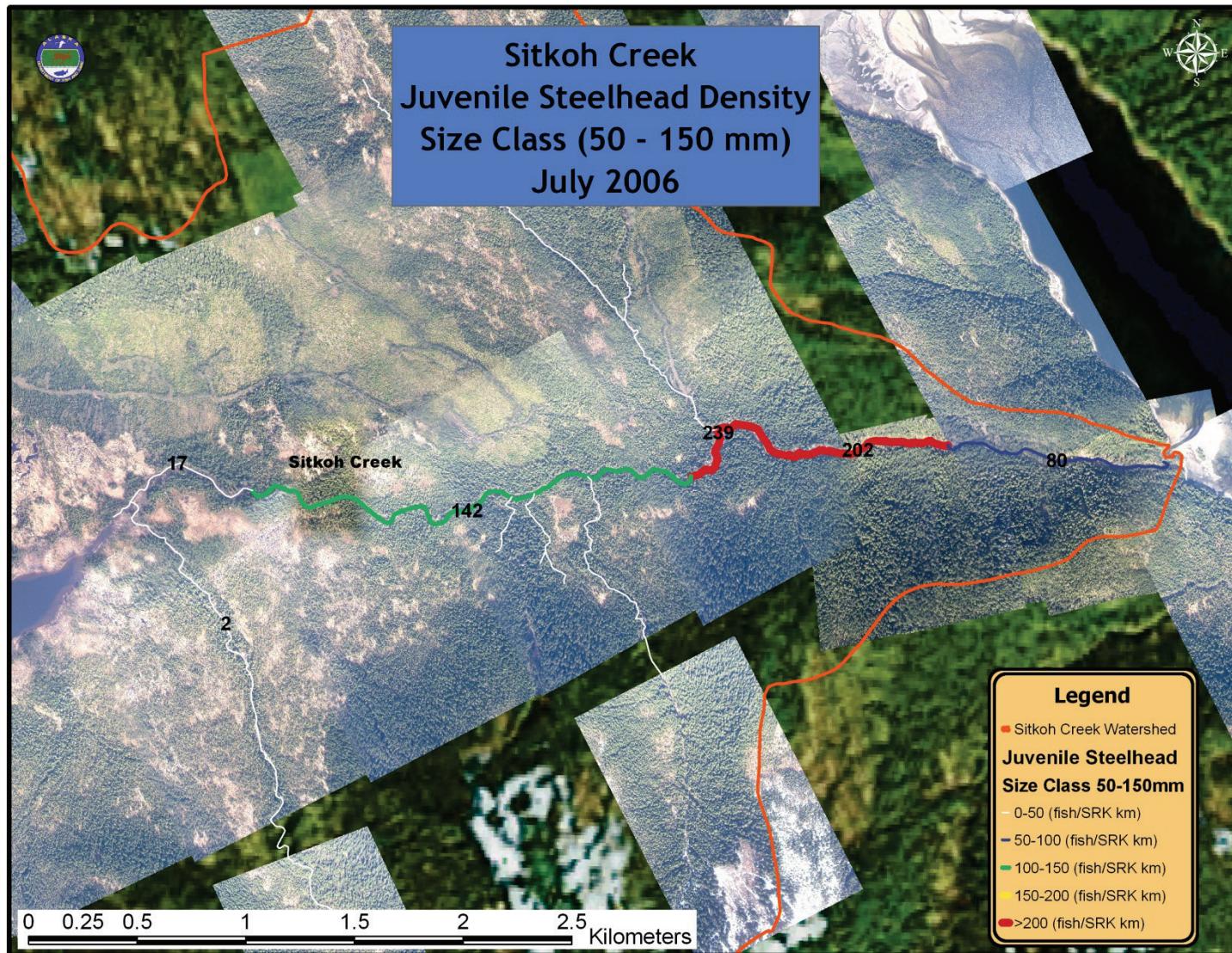


Figure 6.—Juvenile steelhead (50 – 150 mm) observed density throughout Sitkoh Creek in July 2006.

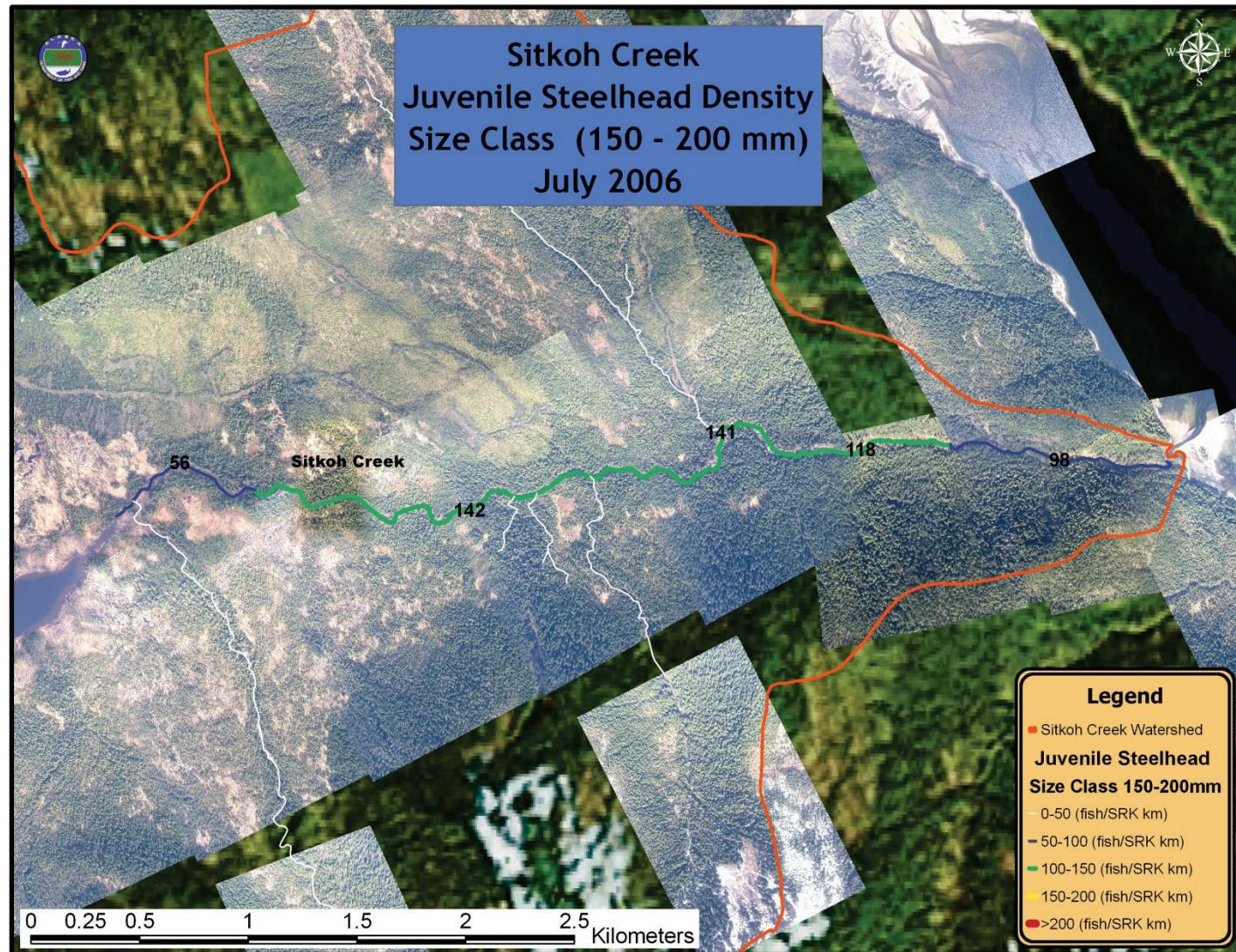


Figure 7.—Juvenile steelhead (150 – 200 mm) observed density throughout Sitkoh Creek in July 2006.

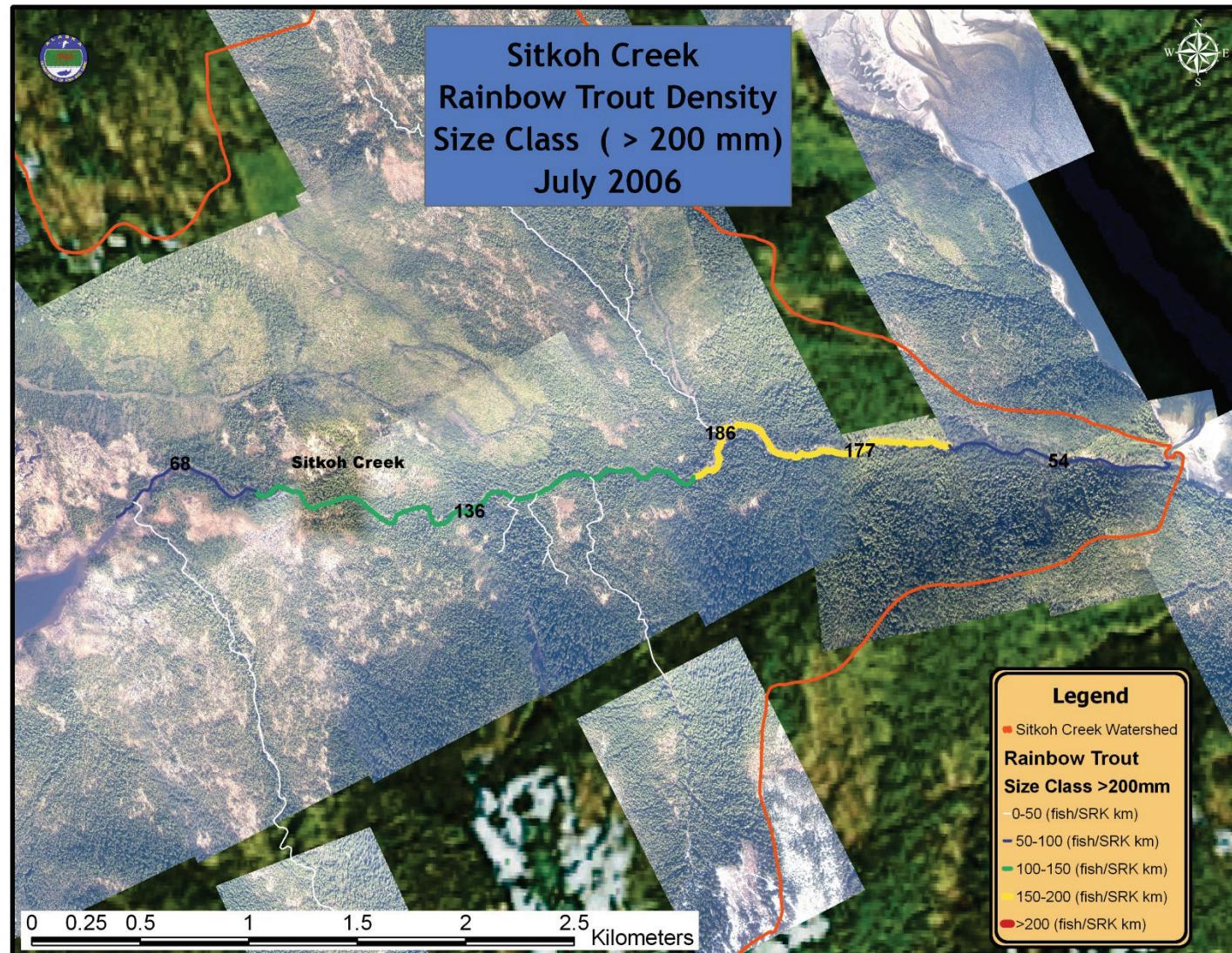


Figure 8.—Rainbow trout (>200 mm) observed density throughout Sitkoh Creek in July 2006.

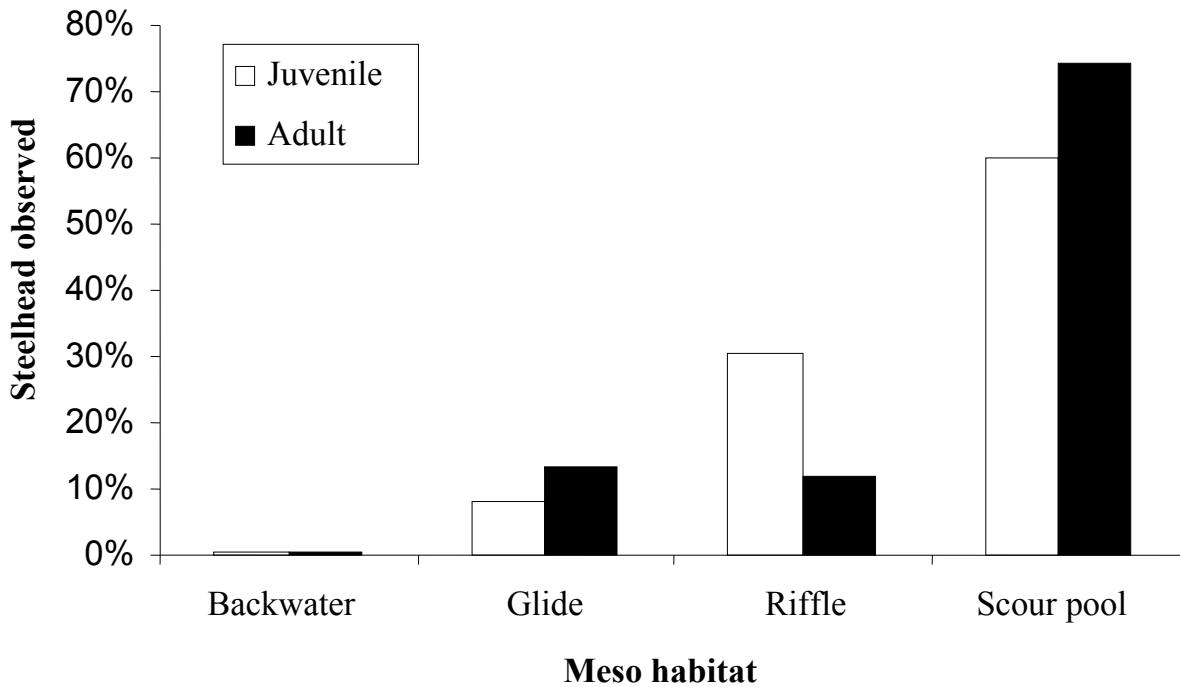


Figure 9.—Meso-habitat occupied by juvenile and adult steelhead in Sitkoh Creek, 2005–2007.

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The development of a steelhead habitat capability model for SEAK will be a useful tool for fisheries managers, as it will help improve understanding of steelhead production in terms of available habitat. The main contribution of this study is the calculation of steelhead usable habitat area from direct observation of occupied habitats. The amount of usable habitat area is important as it relates to concurrent stock assessment work necessary to generate an estimate of the number of adult and juvenile steelhead per unit usable area. While the goal is similar to the Tautz et al. (1992) study, our approach of verifying fish use and physically measuring usable habitat area is empirically based and represents an improvement in the applicability of information that may be used for management decisions. As we develop this relationship for 8 steelhead watersheds throughout SEAK, it is important to recognize that this Sitkoh Creek data represent just 1 lake system in the northern portion of SEAK. The full utility of this model will be realized once we incorporate long-term production and habitat data from a variety of steelhead systems throughout SEAK. Additional short-term achievements of this project include: high-resolution base layer imagery of the watershed; mapped and updated stream hydrography; additional length and species compositions leading to updates for the AWC; and improved knowledge of various species' distribution patterns and habitat relationships.

Table 6.—Adult steelhead escapement and smolt emigration in Sitkoh Creek, 2003–2009.

Year	Adult steelhead	Smolt steelhead
2003	682	3,162
2004	780	3,742
2005	574	2,230
2006	416	3,561
2007	416	1,704
2008	511	1,751
2009	408	890
Mean	541	2,434

Comparison of the carrying capacity results from this study to predictions of other authors working on similar models is challenging due to the differences in model parameters. Tautz et al. (1992) indicated that the Keogh River produced 0.058 smolt/m² or 580 smolt/ha of usable area, and Snow Creek in Washington produced 0.039 smolt/m² or 390 smolt/ha, both substantially more than the 158 smolt/ha production at Sitkoh Creek. Tautz et al. (1992) calculated usable area as the product of stream reach length and estimated wetted width during summer low flows and found 1,140 ha usable habitat area with this approach. This estimate of usable habitat area, which incorporated only minimum wetted width, could explain some of the elevated production but likely not all, as they report the derived carrying capacities as being 2 – 4 times higher than current run size estimates. The authors therefore included numerous adjustments to generate adult estimates for the Skeena drainage resulting in 92,500 adults, or 81 adults/ha usable area, still more than double Sitkoh Creek’s 35 adults/ha. Cramer and Ackerman (2009b) presented data from 6 steelhead creeks in Oregon and included several habitat quality parameters in their carrying capacity predictions which ranged from 0.01 – 0.06 smolt/m² or 100 to 600 smolt/ha. Sitkoh Creek smolt production is within the lower end of this range at 0.016 smolt/m² or 158 smolt/ha. If the results of these authors are comparable to those of this study then the Sitkoh stock produces fewer fish per unit of habitat area. One possible explanation is that southern stocks are more productive given an increased duration of their growing season and primary production of available prey (Withler 1966). While comparisons between different models may assist in providing some corroboration, the various parameters used in these models are likely not similar enough to afford any meaningful interpretation.

FISH HABITAT USE ASSESSMENT

Repeated seasonal assessment of fish use allowed us to document several stream reaches that would not have been verified for various species by just 1 survey. A good example is the tributary stream reach (F4) that enters the west end of Sitkoh Lake. Timber management practices caused water to divert from the original stream channel bed and meander through a spruce forest alluvial fan and then flow subsurface before connection to the lake. Following a major storm event in 2007, the diversion was breached, and again connected the original stream channel to Sitkoh Lake. This stream reach was then positively verified for the presence of steelhead, cutthroat trout, coho salmon, and Dolly Varden, supporting the approach of repeated seasonal snorkel surveys to verify fish use. We recommend this seasonal approach when verifying fish habitat.

We did not observe a seasonal migration of juvenile steelhead from the mainstem to the tributaries due to increased stream flows as was observed by Bramblett et al. (2002) in Staney Creek on Prince of Wales Island in SEAK. Rather, we found steelhead to be rare or absent in tributaries, which therefore contributed minimally to steelhead usable habitat area. During this study sampling occurred under a variety of seasons and instream flow conditions and we did not detect this migratory behavior. While seasonal differences in flows were not found to affect juvenile steelhead movement, temperature did appear to influence our ability to detect them. We did not observe many fish of any species when water temperatures were below 4° C, a threshold temperature also reported by Bryant et al. (2009). Therefore, we recommend timing these seasonal surveys in the spring after temperatures increase and before late fall when temperatures decrease.

We observed adult steelhead only during the spring months indicating that the Sitkoh Creek system primarily supports ocean-maturing (“spring-run”) fish. While it is possible for there to be a fall/winter component to this stock, it does not appear to be predominant (D.C. Love, Fishery Biologist, ADF&G-SF, Douglas, personal communication). For the purposes of this model, additional fish entering the system during these periods are believed to be insignificant. We also did not observe adult steelhead in any tributary reaches, and we do not believe that it is likely that any additional usable area is occupied by adult steelhead in the tributaries during any season. While we did not observe adults spawning in tributaries within the Sitkoh Creek watershed, their use in other systems is quite possible; therefore we recommend continued surveying of tributaries to ensure the total usable area of other watersheds is fully assessed.

OTHER SPECIES

During our snorkel surveys of the mainstem and tributaries we observed a diversity of fish species within and across all seasons. In the spring when cutthroat trout spawn, they were observed paired in the mainstem as well as in 7 tributary stream reaches. Bryant et al. (2009) also observed seasonal movement of cutthroat trout during the spring into tributary reaches coinciding with spawning, increased stream discharge, and higher stream temperatures. Previous studies have documented segregation between cutthroat trout and rainbow trout/steelhead in time and space (Johnson et al. 1986; Bramblett et al. 2002). In this study, cutthroat trout were more predominant in the tributaries than rainbow trout/steelhead, but there was a high degree of overlap in the mainstem. During all seasons, cutthroat trout were the most widely distributed species in all but 5 surveyed stream reaches. Several small tributaries contained cutthroat trout in just the summer or fall, potentially a result of migratory behavior.

Juvenile coho salmon were absent from more stream reaches than Dolly Varden and cutthroat trout, typically not occupying stream reaches with gradients exceeding 4–5%. While coho salmon were observed in 4 stream reaches with gradient exceeding 5%, these fish were found in sections of the reach with lower gradient. Juvenile coho salmon were not present in these reaches during spring, again potentially due to seasonal shifts in habitat use. Increased flows during fall attracted adult coho salmon into 4 tributary stream reaches, and these fish were observed in spawning condition. Stream gradient within these reaches and the mainstem were all very similar, ranging between 1.2–2.2%. Similarly, substrates were fairly homogeneous and dominated in these reaches by coarse gravel, cobble, and sand/silt mixtures.

During our fall snorkel surveys, we observed the majority of fish in the mainstem stream reach nearest Sitkoh Lake and found fewer fish distributed throughout the lower mainstem than in

other seasons, suggesting a migration to Sitkoh Lake for overwintering. We also observed Dolly Varden in spawning condition and commonly paired in the upper extents of 5 tributaries in the fall. Many small tributaries were also occupied by Dolly Varden fry (30–50 mm) during the summer surveys.

We believe it is important to document the methods used in this study and report the results of other species observed as it would be practical to apply this habitat modeling approach to other trout, char and salmon species in SEAK.

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APPENDIX A

Appendix A1.–Size classes and codes used for identification of dominant substrates.

Substrate	Code	Size class
Organic	ORG	Organic
Sand/Silt	SS	<2mm
Very Fine Gravel	VFG	2–3.9mm
Fine Gravel	FGR	4–7.9mm
Medium Gravel	MGR	8–15.9mm
Coarse Gravel	CGR	16–31.9mm
Very Coarse Gravel	VCG	32–63.9mm
Small Cobble	SC	64–127.9mm
Large Cobble	LC	128–255.9mm
Small Boulder	SB	256–512mm
Large/Med Boulder	LMB	>512 mm
Bedrock	BR	Bedrock

APPENDIX B

Appendix B1.– List of computer data files archived from this study.

Data file	Description
Sitkoh_Hydro.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all stream delineation for the Sitkoh Creek watershed
Sitkoh_Lake.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all lake delineation for the Sitkoh Creek watershed
Sitkoh_Features_ALL.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all mapping features encountered during stream habitat surveys within the Sitkoh Creek watershed.
CBW_GIS_FinalFDS.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all Channel Bed Widths (CBW's) measured in the Sitkoh Creek watershed.
Sitkoh_FOP_ALL.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all Fish Observation Points (FOP's) observed during snorkel surveys within the Sitkoh Creek watershed.
Sitkoh_Subbasins.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing all sub-basin delineation for the Sitkoh Creek watershed
Sitkoh_Creek_Watershed.shp	GIS shapefile (State Plane, NAD83 FIPS 5001 projection) containing for the Sitkoh Creek watershed.
FDS_SitkohII_DataArchive.xlsx	Excel spreadsheet containing data for Sitkoh Phase II FDS report tables and figures.

Note: Data files are archived with ADF&G, Division of Sport Fish Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska.